STATE OF ILLINOIS

HENRY HORNER, Governor

WELLS

DUG, DRILLED, AND DRIVEN

Location and Construction for a Safe Water

Division of Sanitary Engineering

ILLINOIS DEPARTMENT OF PUBLIC HEALTH

ALBERT C. BAXTER, M. D., Acting Director

Springfield

Educational Health Circular—No. 14

(REVISED OCTOBER, 1937)

[Printed by authority of the State of Illinois.]

DUG, DRILLED AND DRIVEN WELLS

Carl D. Gross, Assistant Sanitary Engineer
H. A. Spafford, Assistant Sanitary Engineer (Portion on Buried Slab Well)
Clarence W. Klassen, Chief Sanitary Engineer

Location and Construction for a Safe Water.

Wells used as sources of water for drinking or domestic purposes should always be so located and constructed as to yield a safe water at all times. Because many automobile tourists drink water from private and semi-public wells, it is more important than ever that such wells be satisfactory. A well is a permanent structure, often used for several generations, and should be made and kept pollution-proof. An improperly protected well may not cause illness for years but may suddenly become dangerously polluted and cause illness and death. Typhoid fever, a filth disease which is sometimes water-borne, has cost Illinois people nearly $1,000,000 per year. It costs but little more to construct and maintain a safe well than one subject to pollution. Safe construction is cheap health insurance. Why invite preventable illness and gamble with death?

A water can be safe and yet not clean, that is it might be free from disease-producing germs even though it contained miscellaneous dirt. Drinking water should be both clean and safe. Therefore, the well should be protected from all kinds of contamination. Proper location will avoid underground pollution such as seepage from a privy vault or sewer. Proper construction will exclude surface contamination such as filth from shoes, animals or surface water.

Inspections of thousands of private wells in Illinois indicated that relatively few dug wells and less than one-half of the drilled and driven wells were pollution-proof, that is, would produce a continually safe water.

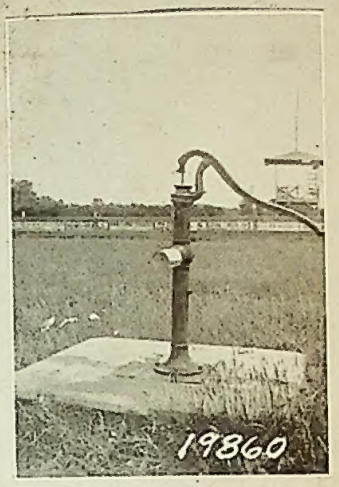
Location of Wells.

Drainage. The well site should have good surface drainage and be higher than sources of pollution such as privies, cesspools and sewers. For school, tourist and other public wells where there is considerable waste pumpage, a drain should be provided to carry this waste water at least 15 feet from the pump to prevent mud puddles.

Privy vaults and **septic tanks** should be at least 50 feet (preferably 100 feet) and **cesspools** at least 75 feet away and on a down slope from the well. **Sewers** or **sink drains** should never be nearer than 25 feet to the well and when within 50 feet should be built with cast-iron pipe with water-tight joints. These minimum distances apply only in clay or loam soils. Sewage travels faster and farther in gravel formations and safe distances would be variable but greater. Creviced limestone or disintegrated rock formations may permit pollution to travel for miles.

Barnyards, etc., should preferably be 50 feet or more from the well and on a downward slope from the well.

Open-top, bucket-and-rope wells invite contamination and illness such as TYPHOID FEVER



WOODEN TOPS or WOODEN MAN-HOLES allow dog pollution and dirt from shoes to contaminate the well water

WRONG PUMP. Two-piece pump bases allow polluted water to splash into the well. VENTILATORS are unnecessary and often dangerous.

SAFE PUMP. One-piece base fits down over PIPE SLEEVE and keeps dog pollution, dirty water, and shoe scrapings out of the well. CUP CONDEMNED.

Fig. 1. DUG WELLS.

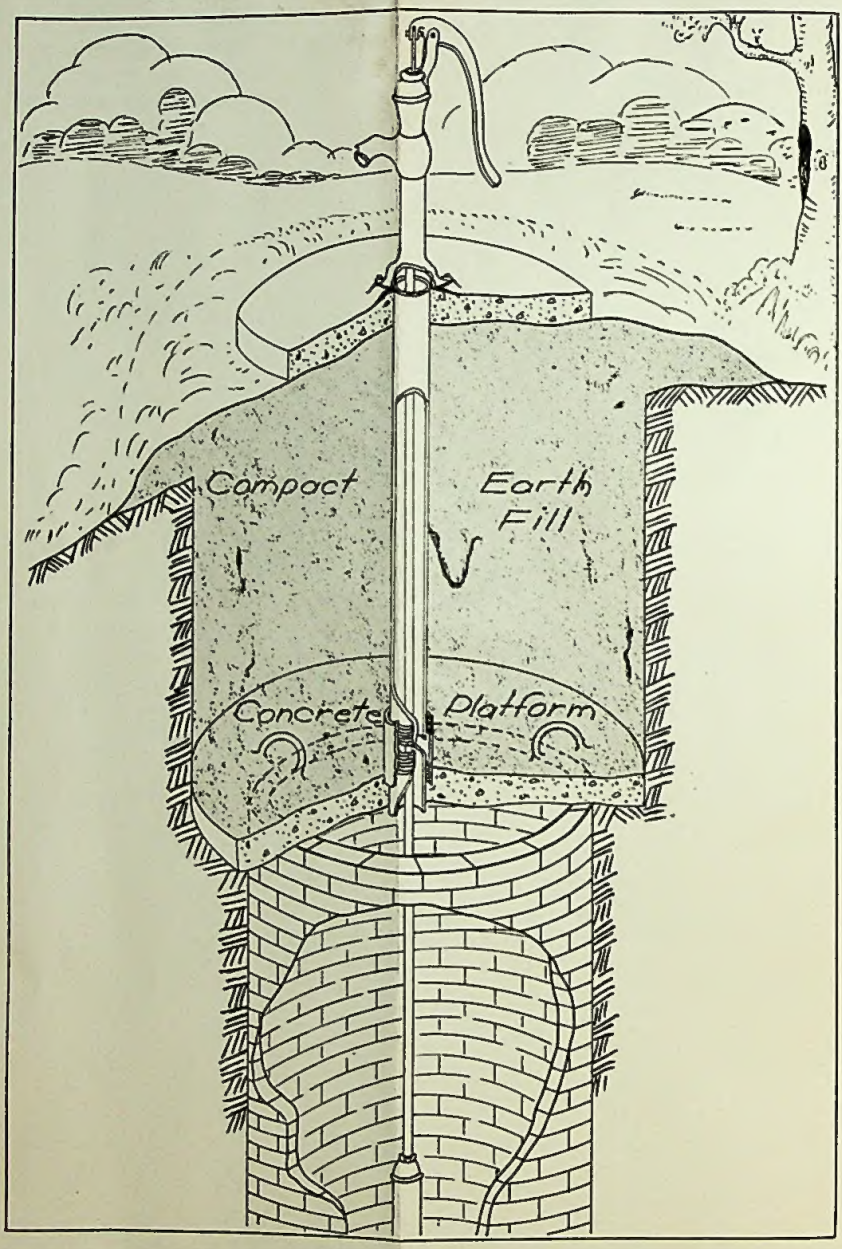


Fig. 2. BURIED SLAB TYPE DUG WELL.

Construction of Dug Wells.

Dug wells are ordinarily more difficult to construct and keep safe, also are sometimes more expensive than driven or drilled wells and thus should be installed only when driven or drilled wells can not be used because of the nature of the water-bearing formations. Any well which is to continuously deliver safe water must be so constructed as to exclude the entrance of all foreign material at the top, and shallow ground water through the upper portion of the well. The upper 8 or 10 feet of ground generally contain bacteria and other contaminating material which must be prevented from entering a well if safe water is to be obtained. Excluding this contaminated shallow ground water drainage is relatively easy in a driven or drilled well, because of the seamless and absolutely water-tight pipe or well casing which serves as the well wall. However, in the ordinary type of dug well, masonry walls of stone, brick or tile have generally been used and it is almost impossible to make such a wall permanently water-tight even when laid in cement mortar by expert workmen. To eliminate this difficulty the buried slab type of dug well has been developed. It is readily adaptable either to new well construction or in repairing an existing dug well.

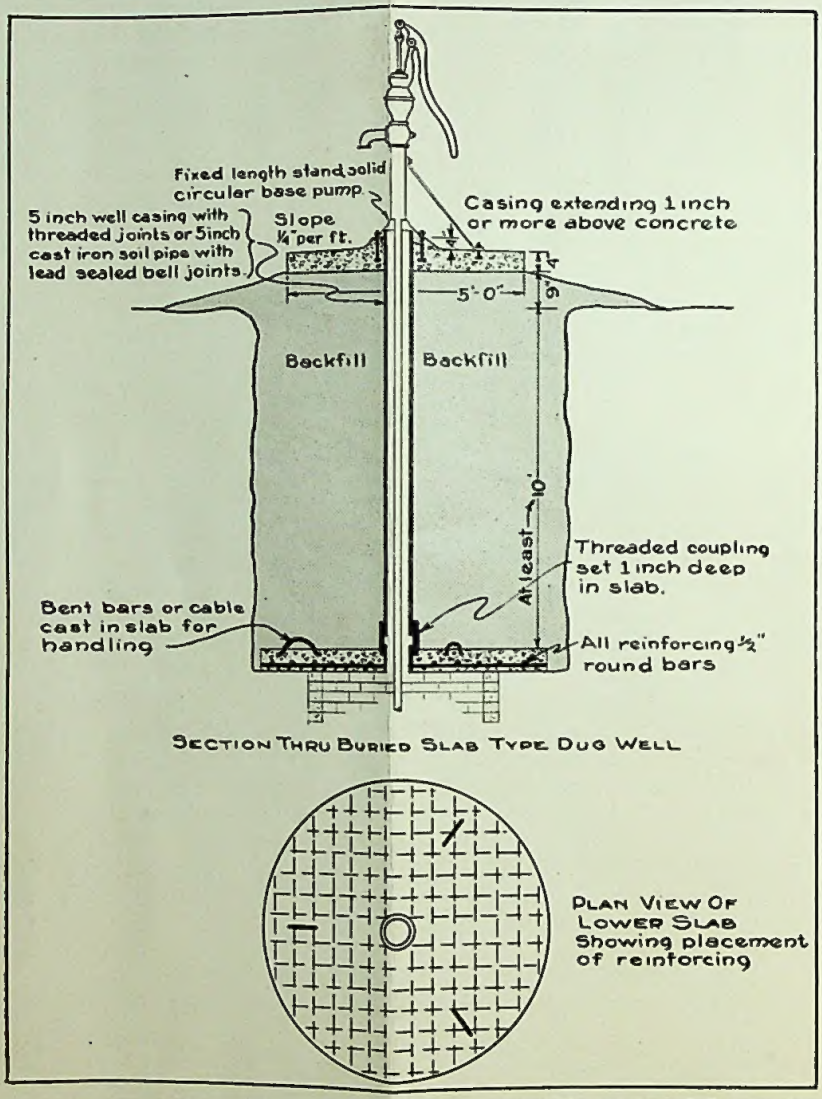
The buried slab type of dug well is shown in Figure 2 on the opposite page. This figure gives a general idea of the construction of this type of well. The well is lined with loose laid brick from the bottom of the well to a point 10 feet (or deeper) below the ground surface. No attempt is made to make this portion of the well wall water-tight. At the 10-foot level is placed a reinforced concrete slab. The slab rests on a clay or earth shelf which is level with the top of the brick wall. This requires the upper 10 feet of the well hole to be about 3 feet larger in diameter than the lower part or well proper.

The concrete slab is cast on the ground surface near the well and after the concrete has thoroughly set (at least a week) the slab is placed in the well with an automobile wrecking crane or a tripod hoist. Concrete mixture of 1 part Portland Cement, 1 part sand and 2 parts gravel or crushed rock is recommended. This mixture is richer than usual but it is necessary to obtain an especially strong slab. One-half inch reinforcing steel rods are placed in the **lower** part of the slab, running in both directions. Spacing of rods, diameter and thickness of slab are shown in Figure 3 and the table below.

DIMENSIONS OF WELLS OF DIFFERENT DIAMETER

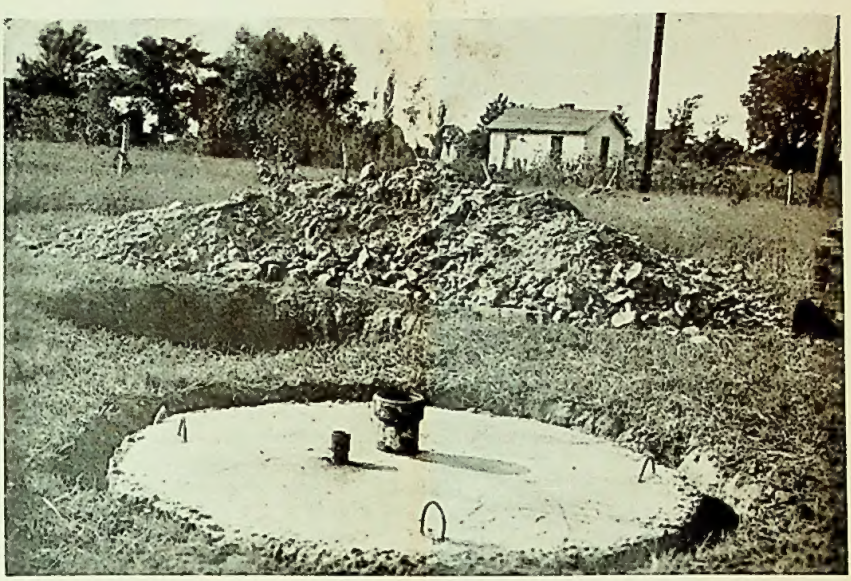
Diameter of well in feet	Diameter of top excavation	Diameter of slab	Thickness of slab—inches	Spacing of reinforcing in inches center to center of bars*
3	5 ft.-0 in.	4 ft.-6 in.	4	6
4	6 ft.-6 in.	6 ft.-0 in.	5	5
5	8 ft.-0 in.	7 ft.-6 in.	5	5
6	9 ft.-6 in.	9 ft.-0 in.	6	4

*All reinforcing to be ½ inch round bars placed at specified spacing in both directions.

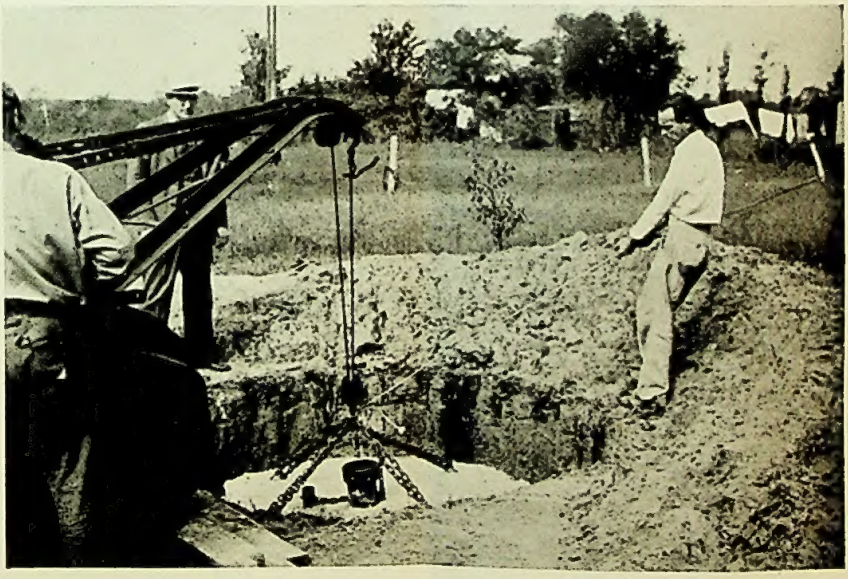


NOTE: See table on page 5 for spacing.

Fig. 3.



Pre-cast concrete slab ready to be placed in well shown in background. Notice iron loops for attaching hoist chains, shown in picture below. Also notice short section of well casing cast in center of slab.



Pre-cast concrete slab being lowered into well by automobile wrecking crane.

Fig. 4.

A one-foot length of 5-inch well casing with the upper end threaded and a coupling attached, should be placed in a **vertical position** in the center of the slab when it is cast.

After the slab is placed down in the well the "casing" is extended to a point at least one foot above the original ground surface, by screwing (or leading) about 10 more feet of 5-inch casing to this short section cast in the center of the slab. A total of about 11 or 12 feet of 5-inch casing or heavy pipe is required, cut into at least two lengths; one, 1-foot long and the other about 10 feet long, each threaded on one end, so the two may be joined by a coupling. Five-inch cast-iron soil pipe with bell joints caulked with lead can be used in place of threaded pipe if desired. If used, place the bell up. **Under no condition** should tile pipe of any kind be used. The tile will crack and joints **can not** be made permanently **water-tight.** Heavy seamless metal pipe of some kind is **absolutely necessary.** Do not economize on this item.

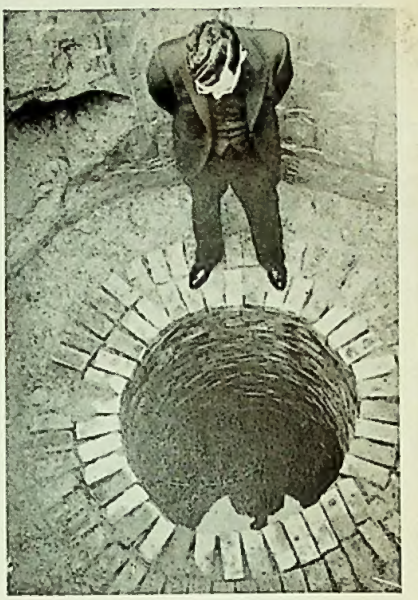
When the pre-cast concrete slab has been placed in the well and the casing installed, the well is ready for back-filling. Earth removed from the well excavation is shoveled back into the top part of the well on top of the pre-cast slab and tamped in place in thin layers to obtain a compact earth fill over the slab. Extreme care is necessary to obtain a well tamped back-fill over the entire 10 feet of depth. The compact earth fill is extended above the original ground surface to make a slight mound 8 to 12 inches high and about 8 or 10 feet in diameter. On top of this mound is placed a plain concrete well platform on which a one-piece base pump is mounted. Caution should be exercised to have the 5-inch well casing top extended at least one inch above this platform and into the recessed pump base, similar to the method used in mounting the pump on a drilled well as shown in Figure 8. After the well is completed it should be sterilized as described on pages 16 and 17. Introduce the proper dose by pouring it into the well through the 5-inch casing just before the pump is finally bolted to the platform. Pictures shown on pages 7 and 9 show the various steps of construction.

A well properly located and built strictly according to these directions should deliver safe water for many years, except for usual periodic pump repairs.

Construction of Ordinary Type Dug Well.

The buried slab type of dug well has many advantages from a health standpoint but if the ordinary or conventional type of dug well is desired and is to be constructed or repaired, each of the following items is important and should be followed, otherwise this ordinary type of dug well will not be pollution-proof.

The wall should be water-tight to a depth of 8 feet or more below the ground surface in order to exclude contaminated shallow ground water. A reinforced Portland cement concrete wall 6 inches thick, made with 1 part cement, 1½ parts sand and 3 parts gravel is satisfactory. Brick, tile or concrete pipe walls are not satisfactory but may be used as interior forms for pouring a 6-inch concrete wall.



Well ready for buried concrete slab to be placed. Notice loose-laid brick wall is laid up to clay shelf on which man is standing. Pre-cast concrete slab to be placed on this shelf, which is 10 feet below ground surface.

Well ready to fill with tamped earth. Man is standing on pre-cast slab which has been placed in well on clay shelf, 10 feet below ground surface. Well casing has been extended above ground surface. Hand well pump will be inserted through this 5-inch casing. Small pipe is for direct suction pressure pump in house basement. Only necessary where water pressure system is used.

If the wall is not water-tight, bacterial analysis will show pollution at certain seasons, the water may contain small white worms, or may taste and smell bad after the well has stood idle for weeks.

The well top should be of water-tight concrete and at least one foot above the surrounding ground level. The concrete top should be not less than 4 inches thick and should extend one foot beyond the well wall in all directions. The concrete should be 1 part cement, 1½ parts sand, 3 parts gravel and must be reinforced with steel to prevent it from cracking. Fig. 6 shows ⅜-inch steel rods placed 9 inches apart both lengthwise and crosswise of the top. No. 9 wire laid 6 inches apart both ways, or a double layer of heavy woven wire may be used instead of steel rods.

Manholes are usually unnecessary and often admit pollution to the well. If a manhole is built, the sides of the opening should extend at least 2 inches above the well top and the manhole cover should be a solid, water-tight lid of iron or reinforced concrete with overhanging edges extending down to the well top. The cover should be firmly bolted or locked in place. If a proper type of iron manhole frame and cover can not be purchased, a concrete manhole as shown in Fig. 6 may be easily built.

The pump-opening through the well top should be formed by a short iron pipe which will extend at least one inch above the concrete and into the pump base to keep waste pumpage, filth from shoes, animals, etc. out of the well. Fig. 6. This pipe should be large enough to admit the pump cylinder and should be placed in the well top when the concrete is poured. Gaskets placed under the pump base will eventually become loose and are unsatisfactory.

Hand pumps should be of fixed length with a one-piece recessed base to fit over the iron pipe in the well top opening. Figs. 1 and 6. The pump cylinder should be placed below or near water level to avoid priming. The pump base should be fastened rigidly to the well top. Chain pumps or bucket-and-rope draws are unsatisfactory.

Construction of top. For wells greater than 4 feet in diameter the top may be too heavy to move and probably should be constructed in place on the well. Small tops may be made separately and then placed on the walls, provided that sufficient fresh cement is placed between the walls and top to make a tight joint.

Make a wooden form with sides at least 4 inches high. Place an iron pipe for the pump opening on the form floor. If a manhole is desired, place a form for the inside of the manhole. Mix 1:1½:3 concrete of jelly consistency, pour it one inch deep upon the form floor, packing it well around the iron pipe, manhole and all sides. Lay reinforcing steel upon the concrete. The steel should be bent up into the manhole neck as shown in Fig. 6. Pour the remainder of the concrete, trowel surface slopes and raised portion for the pump base, allowing the iron pipe to extend one inch above the concrete. Embed bolts for the pump base in the proper place by means of a wooden pattern of the base. Lay an outside form for the manhole neck and fill the space with concrete, inserting a No. 9 wire around the neck about one inch from the top. After the concrete has set, place forms for sides and bottom of the manhole cover, protecting the concrete surface of the well top and neck with tar paper. Pour the concrete, reinforcing it with No. 9 wire 4 inches apart both ways (Fig. 6). After the concrete cover has set, it may be easily removed from the tar paper.

A ventilator upon a dug well is unnecessary, may cause pollution, and none should be built.

Construction of Drilled Well.

Read page 2 first.

Drilled wells, properly cased, are not as subject to contamination as are dug wells. Drilled wells ending in sand, gravel or sandstone will yield a safe water if proper precautions have been observed in selecting the site.

Drilled wells entering limestone formations are to be regarded with suspicion. Limestone deposits are often cracked or fissured and contain caverns. Sometimes surface sink holes connect with the limestone deposits so that polluted water entering such sink holes may travel hundreds of feet or even miles without becoming purified.

The top should be at least one foot above the surrounding ground level in order to provide proper drainage from the well.

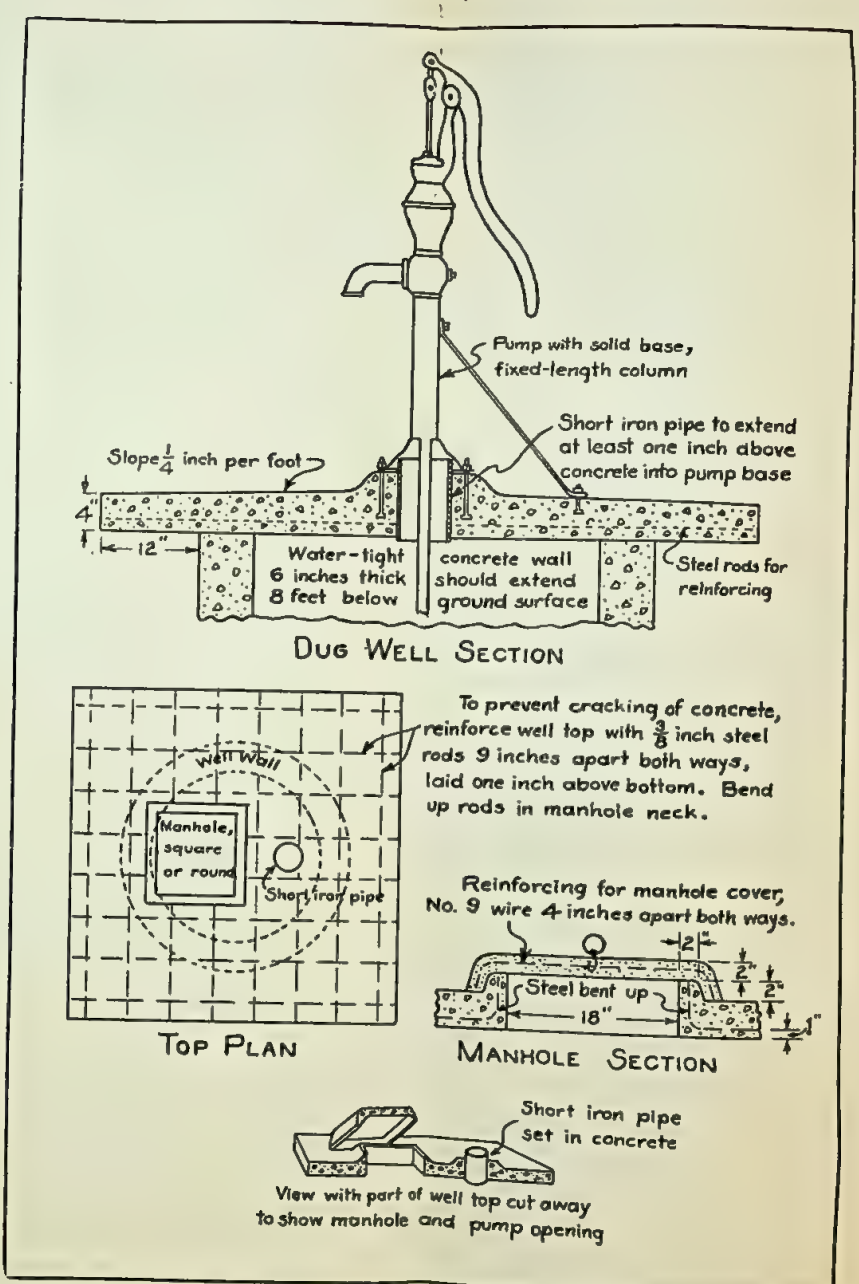


Fig. 6. DUG WELL.

DANGEROUS. Two-piece pump base permits pollution of dug or drilled well but may be safe for sand-point well. Wooden top not approved.

PITCHER PUMP UNSAFE for public use. Open spout invites pollution by dust, birds, and lip drinking. Careless people may use dirty water for priming.

GOOD CONSTRUCTION at pump base. Concrete is raised and drilled well CASING or dug well PIPE SLEEVE extends into pump base.

Artesian water flowing under natural pressure from sand, gravel, or sandstone formations is usually germ-free and safe.

Fig. 7. DRILLED AND DRIVEN WELLS.

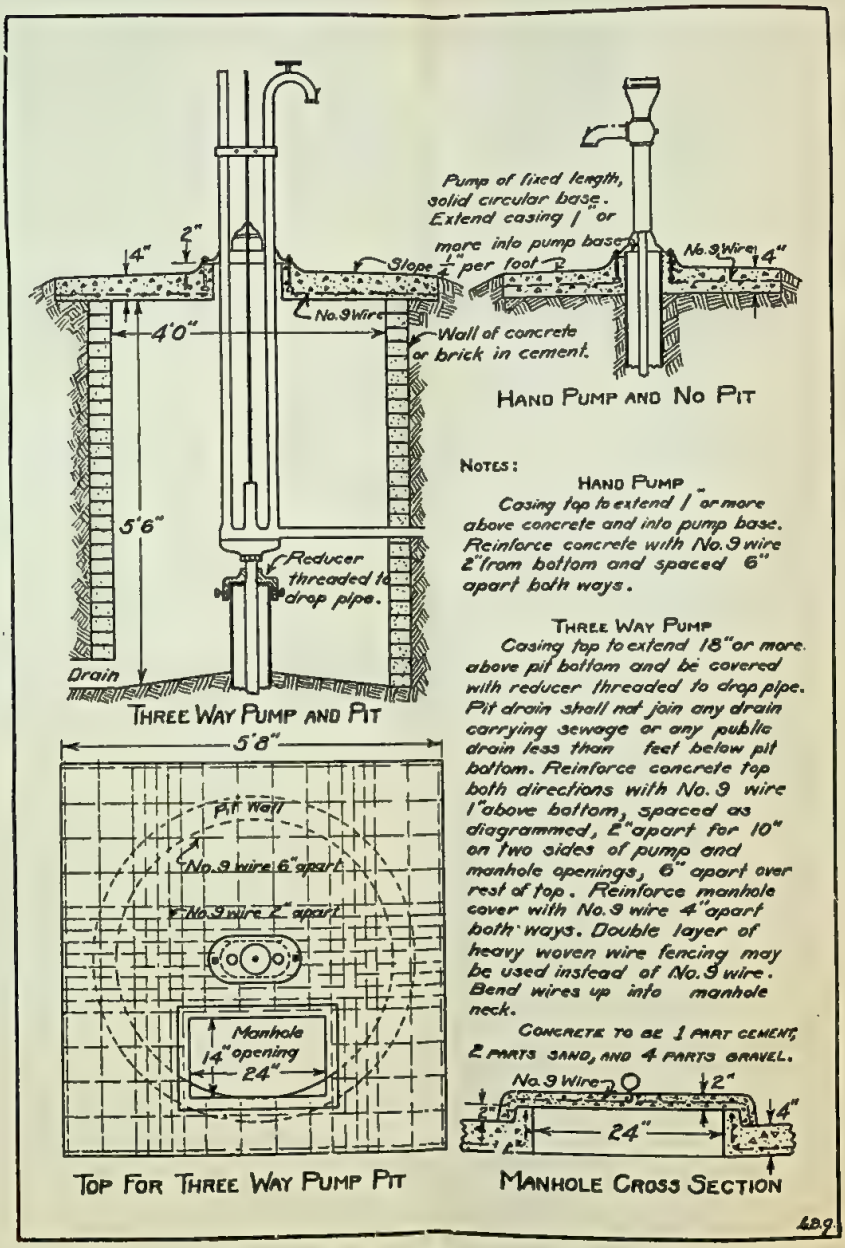


Fig. 8. DRILLED WELL.

The casing should be threaded-joint iron pipe. Tile, wood or sheet metal well casing is certain to admit seepage and make the water of questionable quality. If solid rock is encountered and the casing ends at a depth of less than 10 feet from the ground surface, the casing must make a water-tight union with the rock. In case the upper rock stratum consists of creviced limestone, the casing should extend through such creviced formation to solid rock.

Hand pumps should be a fixed length, one-piece base type with an enclosed water chamber and should be equipped with a stuffing box on the pump rod. A concrete platform should be poured around the casing, bolts for fastening the pump base being placed in the fresh concrete. **The casing top** should extend one inch or more above the concrete surface and into the pump base. Fig. 8. **Pump pits** should be avoided unless the installation of a special pump such as a three-way pump requires a pit. The pit top should be of concrete and the wall of concrete or brick laid with cement. The casing top should be 18 inches or more above the pit bottom. A pit drain should not be constructed unless a free, separate outlet, safe from flooding at highest water stages can be obtained. Well-pit drainage should never under any circumstances connect to any sewer or drain because sewage or storm water may back into the pit and pollute the well. If satisfactory pit drainage can be provided, the casing top should be covered with a reducer fitting threaded to the drop pipe. In undrained pits a water-tight union must be made between the casing and drop pipe either by means of threaded and flanged fittings secured from the pump manufacturer, or by a reducer fitting threaded to both the casing and drop pipe. Fig. 8.

Construction of Driven Well.

Read page 2 first.

Driven wells are satisfactory in regions where water can be secured from sand and gravel deposits. The cost of driven wells is comparatively low and they are more easily protected from contamination than are dug wells.

The well top should be at least one foot above the surrounding ground level in order to provide proper drainage from the well.

The pump should have an enclosed water chamber. Pitcher pumps are open to pollution by birds, dust, hands, priming with dirty water by careless persons, etc., and are not satisfactory. The pump base should be rigidly fastened to the well top. If the pump base is not rigid, repeated use of the pump may loosen the soil around the drop pipe and permit contaminated waste water to flow down along the pipe and pollute the source of water supply.

A frost pit, if one is built, should have a concrete top and a pit wall of concrete or brick laid in cement. Fig. 9.

Any "weep hole" or "bleeder" drilled in the drop pipe to drain the pump should be tapped and fitted with a brass petcock which should be kept closed except during freezing weather. The "bleeder" petcock should be over 18 inches above the bottom of the pit.

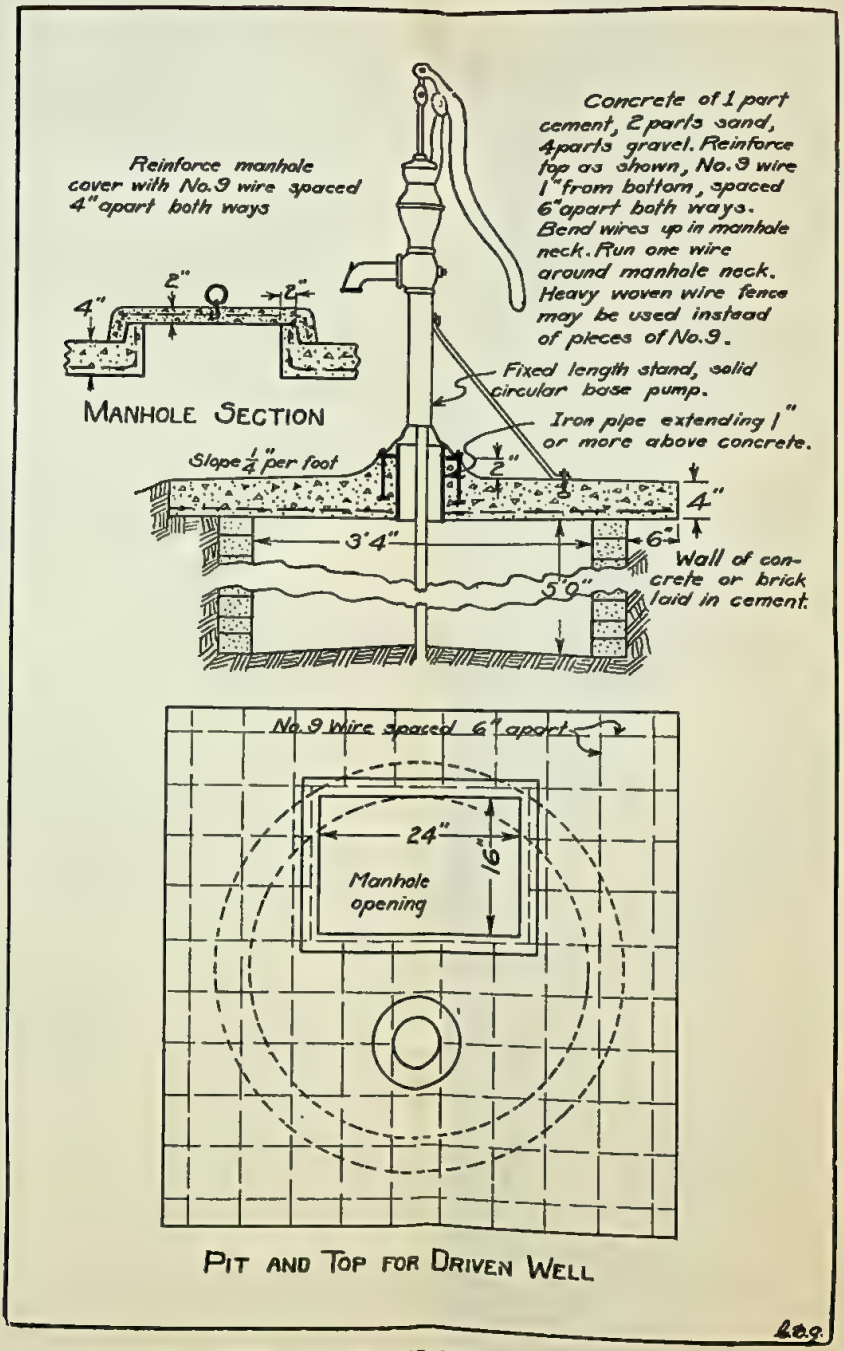


Fig. 9. DRIVEN WELL WITH FROST PIT.

ANALYSES.

When a well is located or constructed so that it is subject to contamination by waste pumpage, surface drainage, shallow ground water or in any other way, an analysis is of no value and thus a waste of time and money. Such a well must be regarded as an unsafe source of drinking water even though analyses of some samples may indicate that portions of the water are safe sometimes. When the Sanitary Engineering Laboratories of the State Department of Public Health receive a request that an analysis of a sample of well water be made, a simple form is sent to the writer upon which to give important information about the location and construction of the well. If on review of the information by engineers, bacteriologists or chemists (who have had experience on inspections and analyses of samples from thousands of wells) it appears that the well should furnish a safe water, a container is sent so that a suitable sample can be collected and analyzed to confirm the conclusions as to the safety of the water and the source from which it is collected. If the information reveals that the well is defective, definite suggestions are made to the owner or user in order that the defects may be corrected before a confirming analysis is made. If an analysis were made first the defects would still have to be corrected to assure a safe well, followed by a second analysis, and the first analysis would be a waste of public funds.

Analyses of water are made free but the samples must be collected in the special sterilized containers furnished by the Sanitary Engineering Laboratories of the Department of Public Health and the person desiring the analysis pays the postage both ways on the container (maximum 35 cents).

Wells, cisterns and basins around springs are often contaminated during construction, repairing or cleaning and may remain contaminated for weeks unless sterilized. Therefore, new wells, cisterns, spring basins and those which have been recently repaired or cleaned, should be sterilized with chloride of lime before an analysis is requested. Before collecting a sample for analysis after sterilizing with chloride of lime, the treated water should be pumped out so that a representative sample of the untreated water can be collected.

INSTRUCTIONS FOR STERILIZING WATER FROM WELLS, CISTERNS OR SPRINGS

Contaminated water in or from an unsafe well or cistern may be made safe by careful sterilization. **However, any process of sterilization should be considered as a TEMPORARY MEASURE if the contamination can be prevented and immediate steps should be taken to reconstruct the source of supply so that it will be protected against further contamination. Disease may result if sterilization is incomplete at any time.**

Water from a well, cistern, or spring which is suspected of being contaminated should be sterilized before it is used for drinking or culinary purposes. The easiest and surest method is to boil the water. It is not necessary to boil for any great length of time, but be sure that it

comes to a distinct boil. The flat taste which results may be partially removed by pouring the water from one clean vessel into another several times, or by adding a pinch of salt.

Because it is not convenient to boil a large amount of water, it is sometimes more desirable to sterilize the entire well or other supply by the use of Calcium Hypochlorite, commonly known as Chlorinated Lime or Bleaching Powder. This chemical can be purchased at any local drug store in small sealed tins. Obtain a fresh supply because the chemical deteriorates somewhat upon standing, even though sealed. When the can is opened a decidedly pungent odor should be evident. This is due to free or available chlorine which usually amounts to about 25% by weight.

Add two ounces of Calcium Hypochlorite for each 1,000 gallons of water to be treated. If scales are not available the material can be measured with a spoon. A moderately heaping tablespoonful of Calcium Hypochlorite (that is with the powder about one inch deep in the center of a spoon) weighs approximately one ounce. The amount of water present in a circular well or cistern can be determined from the following table:

Diameter of well in feet.....	1	2	3	4	5	6	7	8
Gals. for each foot of water in well..	6	24	53	94	147	212	288	376

Rub up the dry powder with a small amount of water to make a thin paste, taking care to break up all lumps, and stir this paste into a bucketful of water. This had best be done out-of-doors to avoid chlorine fumes which are evolved. Pour part of the contents of the bucket into the well and if possible agitate the water to insure thorough mixing. With the remainder rinse down the walls of the well. Allow the water to stand for a period of several hours before using.

The above treatment corresponds to a dosage of 4 parts per million of available chlorine and should impart a slight taste to the water, but this taste is entirely harmless and serves to indicate that sufficient chlorine has been added to adequately sterilize the water. In fact unless a pungent odor or taste is evident, repeat the treatment. It must be borne in mind that such a procedure will sterilize only the water which is actually present in the well at the time of treatment. New water flowing into the well, especially if contaminated, will absorb the free or residual chlorine remaining in the well, and consequently another chlorine treatment would soon be necessary.

Treatment with Calcium Hypochlorite can not produce safe water in a well, spring or cistern if a privy vault, cesspool or sewer is located too close, because underground seepage may cause dangerous pollution of the water at any time.

A newly constructed or repaired well should always be sterilized with a solution ten times stronger than the above before the top is sealed. Rinse or wash the walls with this strong solution.

For sterilizing small quantities of water rub a moderately heaping teaspoonful of Calcium Hypochlorite with a small amount of water in

the manner indicated above and add sufficient water to make a pint. Of this solution use one tablespoonful for each ten gallons of water to be treated, or 36 drops to the gallon.

The U. S. Army Medical Corps has found that two drops of ordinary tincture of iodine (7%) added to a quart of water will destroy all disease germs and render the water safe for drinking purposes in one-half hour.